

A Comparison of the Summer Plankton on the West Coast of Scotland with that in the Irish Sea. By Prof. W. A. HERDMAN, D.Sc., F.R.S., F.L.S.

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DURING the last four summers (1907–1910, incl.) I have spent the first few weeks (July) of the vacation in taking plankton hauls from the

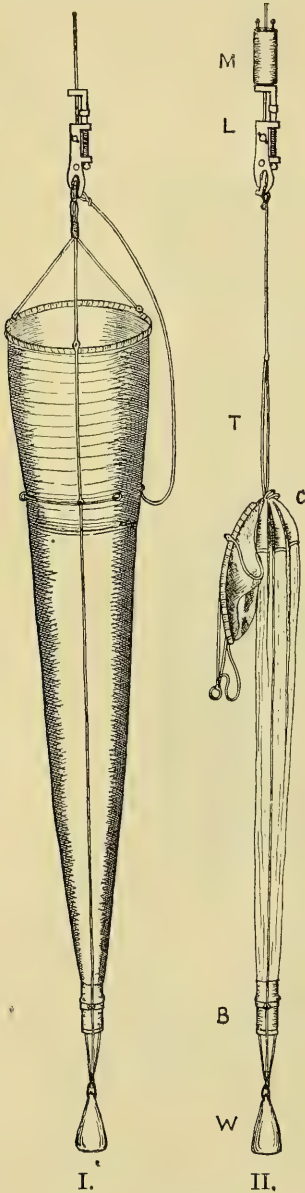


FIG. 1.—“Nansen” Closing Tow-net in action.

I. Open, as it descends and as it fishes.

II. Closed, as it is hauled in after fishing.

M, messenger to effect closing ;

L, releasing apparatus ;

T, throttling noose ;

C, canvas front to net ;

B, brass bucket containing the catch ;

W, weight.

S.Y. ‘Ladybird’ amongst the islands and sea lochs of the west of Scotland, and the remainder of the time (in August and September) in similar work

further south, in the Irish Sea. A comparison of the collections leads one to the conclusion that in addition to seasonal changes there may be marked local differences in the plankton, so much so as to give a characteristic appearance to the gatherings from certain localities.

The plankton hauls from the yacht were in all cases taken with the same nets and in the same method, and the after-treatment was also always the same ; so that the various gatherings are as nearly comparable as is possible. All the vertical hauls were made with the smaller "Nansen" net, a closing-net (fig. 1) of no. 20 silk, with the mouth 35 cm. in diameter.

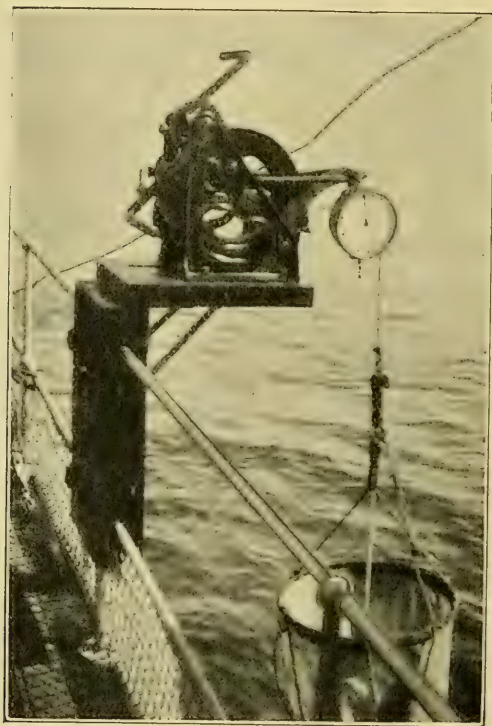


FIG. 2.—Lucas Sounding-Machine as used with Nansen Vertical Closing Net on 'Ladybird.'

Surface gatherings were sometimes taken at the same time with ordinary open surface tow-nets made of the same silk as the "Nansen" net and of approximately the same size. The Lucas Sounding-Machine (fig. 2) fitted with 200 fathoms of pianoforte wire was found to be most convenient and expeditious in taking these deep vertical hauls.

The temperature of the surface water of the sea in the Hebrides varied this summer during the month from 11.8° C. on July 11th, off Canna, to

13.1° C. on July 19th, off the N. point of Eigg. During the same period the surface temperature off Port Erin in the Irish Sea ranged from 11.6° C. to 13.8° C.

As my main object was to obtain samples of vertical hauls from the deeper parts of the British seas, I selected localities off the West Coast of Scotland where the charts showed depths of over 50 fathoms, and where possible of over 100 fathoms. In addition to surface gatherings and the Irish Sea series, I have now 33 successful vertical hauls in Scottish waters from depths of over 50 fathoms and 18 from over 100 fathoms (see fig. 8, p. 38) The deepest are :—133 fathoms, between Croulin and Longa Islands in the Sound of Raasay, and 130 fathoms between Canna and Rum, south of Skye.

The localities may conveniently be grouped in three series : (1) those north of Oban, (2) those further south in the Clyde sea-area, and (3) those in the Irish Sea. The northern Scottish series number 41, the southern series 26, and those from the Irish Sea, from depths over 50 fathoms, are 66 *. The list of localities is as follows, arranged according to the day of the month irrespective of years :—

I. NORTH OF OBAN.

- (1) 11-vii-'10; Hyskeir, S. of Canna; surf. (2 hauls).
- (2) 12-vii-'10; Vatersay Sound; surf. (2 hauls).
- (3) 13-vii-'09; Ardmore, N. of Mull; 94 faths.
- (4) 13-vii-'09; Between Canna and Rum; 130 faths.
- (5) 14-vii-'09; Loch Nevis, Sd. of Sleat; 75 faths.
- (6) 14-vii-'10; N. of Canna; 80 and 105 faths.
- (7) 14-vii-'10; Between Canna and Rum; 128 faths.
- (8) 15-vii-'09; L. Hourn, Sd. of Sleat; 76 and 90 faths.
- (9) 16-vii-'09; Between Croulin and Longa, N. of Skye; 133 faths.
- (10) 17-vii-'08; Loch-na-Beist, Skye; 6 faths. all night.
- (11) 17-vii-'08; L. Nevis, Sd. of Sleat; over 70 faths. (2 hauls).
- (12) 17-vii-'08; L. Hourn; 43, 45, 73, and 78 faths.
- (13) 17-vii-'09; L. Duich; 61 faths.
- (14) 18-vii-'08; Holm Isle, Sd. of Raasay; 65 and 70 faths.
- (15) 18-vii-'08; L. Ainnert; 20 and 23 faths.
- (16) 18-vii-'08; L. Sligachan; 12 faths.
- (17) 18-vii-'10; Ardmore, N. of Mull; 65, 74, and 85 faths.
- (18) 19-vii-'10; N.W. of North Pt. of Eigg; 85 faths.
- (19) 20-vii-'08; Longa Island; 106 faths.
- (20) 20-vii-'08; S. of Croulin Isles; 116 faths.
- (21) 21-vii-'07; Sd. of Iona; surf.
- (22) 21-vii-'09; Bernera I., Lynn of Morven; 110 faths.
- (23) 21-vii-'09; Between Kerrera and Mull; 80 faths.
- (24) 21-vii-'10; L. Sunart; 57 faths.

* I have also taken about 200 gatherings in these four years (1907-10) from shallower water in the Irish Sea, and these have been reported on fully in Trans. Biol. Soc. Liverpool, vols. xxii-xxiv, 1908-10.

- (25) 22-vii-'07 ; Sd. of Iona ; surf.
- (26) 22-vii-'10 ; Firth of Lorn ; 108 and 116 faths.
- (27) 22-vii-'10 ; Bernera I., Lynn of Morven ; 110 faths.
- (28) 24-vii-'07 ; L. Scresort, Rum ; surf.

II. CLYDE SEA AREA.

- (1) 18-vii-'07 ; Skate I., L. Fyne ; 104 faths.
- (2) 26-vii-'07 ; Kilbrennan Sound ; 76-80 faths.
- (3) 27-vii-'07 ; East L. Tarbert, off Buddhe I. ; 76 faths.
- (4) 27-vii-'07 ; off Cock of Arran ; 76 faths.
- (5) 27-vii-'07 ; L. Ranza, Arran ; night ; surf.
- (6) 28-vii-'08 ; Skate I., L. Fyne ; 95-105 faths. (3 hauls), and surf.
- (7) 28-vii-'08 ; off Mt. Erins, L. Fyne ; 83 faths.
- (8) 28, 29-vii-'08 ; Newton, Upper L. Fyne ; 54-66 faths. (4 hauls).
- (9) 28-vii-'09 ; Skate I., L. Fyne ; 100-106 faths. (4 hauls).
- (10) 29-vii-'09 ; Upper L. Fyne ; 70 faths.
- (11) 30-vii-'09 ; Sd. of Bute ; 95 faths.
- (12) 30-vii-'08 ; L. Ranza, Arran ; surf.
- (13) 30-vii-'09 ; off Cock of Arran ; 80 faths.
- (14) 31-vii-'08 ; S. of Holy I., Lamdash, Arran ; 54 faths. (2 hauls).
- (15) 1-viii-'09 ; off Portpatrick ; 103 and 106 faths.
- (16) 1-viii-'10 ; off Sannox, Arran ; 70 faths.

III. IRISH SEA.

- (1) 7-iv-'09 ; 60 faths. (4 hauls).
- (2) 8-iv-'09 ; 60 faths. (5 hauls).
- (3) 6-viii-'09 ; 59-60 faths. (5 hauls).
- (4) 7-viii-'09 ; 60-70 faths. (4 hauls).
- (5) 10-viii-'09 ; 60-73 faths. (4 hauls).
- (6) 17-viii-'08 ; 60-70 faths. (6 hauls).
- (7) 24-viii-'07 ; 60 faths. (10 hauls).
- (8) 25-viii-'10 ; 60 faths. (5 hauls).
- (9) 4-ix-'07 ; 60 faths. (12 hauls).
- (10) 12-ix-'07 ; 60 faths. (6 hauls).
- (11) 12-ix-'08 ; 60 and 70 faths.
- (12) 17-ix-'10 ; 70 faths. (3 hauls).

As the same spot was sometimes visited in successive years, many of the gatherings in the list above may be grouped under a few localities, as follows :—

I. NORTH OF OBAN.

- 1. Off Ardmore Pt. in Mull—gatherings : (3) in 1909, and (17) in 1910 (3 hauls).
- 2. Loch Hourn—gatherings : (12) in 1908 (4 hauls), and (8) in 1909 (2 hauls).
- 3. Loch Nevis—gatherings : (11) in 1908 (2 hauls), and (5) in 1909.
- 4. Canna, Rum, etc.—gatherings : (4) in 1909, and (6) (2 hauls) and (7) and (18) in 1910.
- 5. Croulin and Longa—gatherings : (14) (2 hauls) and (19) and (20) in 1908, and (9) in 1909.
- 6. Firth of Lorn, etc.—gatherings : (22) and (23) in 1909, and (26) (2 hauls) and (27) in 1910.

II. CLYDE SEA AREA.

7. Skate Island—gatherings: (1) in 1907, (6) (3 hauls) and (7) in 1908, and (9) in 1909 (4 hauls)
8. Upper Loch Fyne—gatherings: (8) in 1908 (4 hauls), and (10) in 1909.
9. Arran, Sound of Bute, etc.—gatherings: (2), (3), and (4) in 1907, (11) and (14) (2 hauls) in 1908, (13) in 1909, and (15) in 1910.

III. IRISH SEA.

10. All the 58 hauls were in the one locality, 12-16 miles N.N.W. of Port Erin, Isle of Man, from depths of 59 to 73 faths.

When we examine these groups of Scottish gatherings from the same places in different years, two conclusions become evident:—

- (1) That localities, in some cases not very far apart, differ very considerably in the nature of their plankton at the same time of year;
- (2) That there is a constancy year after year in the nature of the plankton at some localities.

A few examples will make this clear:—

- (1) In the northern area, the hauls taken in Loch Hourn and Loch Nevis are on all occasions very different from those taken off Ardmore in Mull, and from those taken off the Island of Canna; also those taken in the Lynn of Morven at one end of the Sound of Mull differ from those taken between Mull and Ardnamurchan at the opposite end. Again, in the southern series, the hauls from off Skate Island, in the entrance to Loch Fyne, differ markedly from those taken further south in the Sound of Bute and the Firth of Clyde off Arran.
- (2) The Loch Fyne vertical hauls are always characterised by the abundance of large Copepoda; the hauls off Canna and elsewhere in the Sea of the Hebrides by the prevalence of Diatoms; those in the Firth of Lorn by a fine zoo-plankton, and those round Raasay on the North of Skye by a much coarser zoo-plankton.

Let us now examine some of these cases in more detail:—

All the vertical hauls taken in the deep hole, 95-106 faths., off Skate Island at the mouth of Loch Fyne, consist of a coarse zoo-plankton (see fig. 3) characterised by a very great number of the common Copepod, *Calanus helgolandicus*. The specimens of *Calanus* are large, and many of them are of a red colour when alive; and associated with them are generally a few *Eucheta norvegica* and one or two specimens of the Schizopod *Nyctiphanes norvegicus*. There are also in these hauls a few smaller Copepoda (such as *Pseudocalanus elongatus* and *Oithona similis*), some Copepod eggs and nauplii,

a few *Sagitta*, a few Echinoderm Plutei and Polychæt Larvæ, *Ceratium tripos*, and some Diatoms, chiefly *Rhizosolenia semispina*. But the bulk of the gathering is, in all cases, *Calanus helgolandicus*, and that gives it a characteristic appearance which can be seen as soon as the net comes up. We have in all eight vertical hauls taken during July in the years 1907, -08, -09, and also a surface gathering taken at the same locality on July 28th, 1908. This surface gathering is, however, of an entirely different character from the vertical hauls. It is greenish in colour, and of fine flocculent appearance, and is in constitution a phyto-plankton (see fig. 4) almost entirely composed of Diatoms, chiefly species of *Rhizosolenia*. There are also a few Peridiniæ,

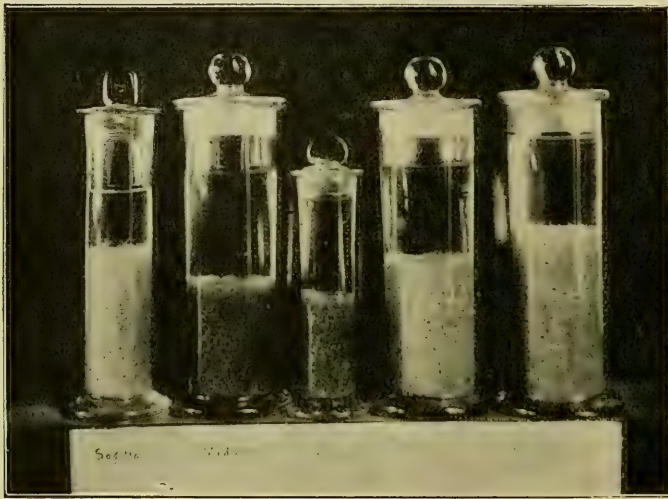


FIG. 3.—Monotonic Zoo-plankton samples, one of which shows *Calanus*.

and a very few small Copepoda, but the larger Copepods characteristic of the vertical hauls are entirely absent.

A vertical haul from 83 faths. taken off Mt. Erins, further up Loch Fyne, on that same date in July, 1908, shows the same type of gathering as the vertical hauls off Skate Island.

It is clear that the *Calanus* population extends in the deep water along the length of Loch Fyne, as hauls taken at various points in Upper Loch Fyne, both in 1908 and 1909, from depths of 54-70 faths., show the same kind of gathering as those off Skate Island. On the other hand, in working down the channel towards Bute, Arran, and Kilbrennan Sound, we find that the gatherings are of a more varied nature. One off Sannox, Arran, on August 1st, 1910, from 70 faths., is a mixture of phyto- and zoo-plankton, and does not contain the large Calanoid Copepoda in any quantity. A haul taken off the Cock of Arran at the same season in the previous year, from a

depth of 80 faths., had a fair number of large Copepoda, mixed, however, with Diatoms (*Rhizosolenia semispina*, *Chaetoceros boreale*, &c.), Peridinians, and some smaller Copepoda. Another haul in the same spot in 1907 is of the same nature, with a still larger proportion of the smaller Copepoda (mainly *Pseudocalanus elongatus* and *Oithona similis*) and their Nauplii. One in the Sound of Bute from a depth of 95 faths., on July 30th, 1908, had along with the Calanoids, and some smaller Copepoda, a very large number of Diatoms (chiefly species of *Rhizosolenia*), so as to be almost a phyto-plankton in appearance. Two hauls taken south of Holy Island, Arran, from 54 faths., in 1908, show also a mixed plankton, consisting of Diatoms and Peridinians along with the Copepoda. A haul from 80 faths.

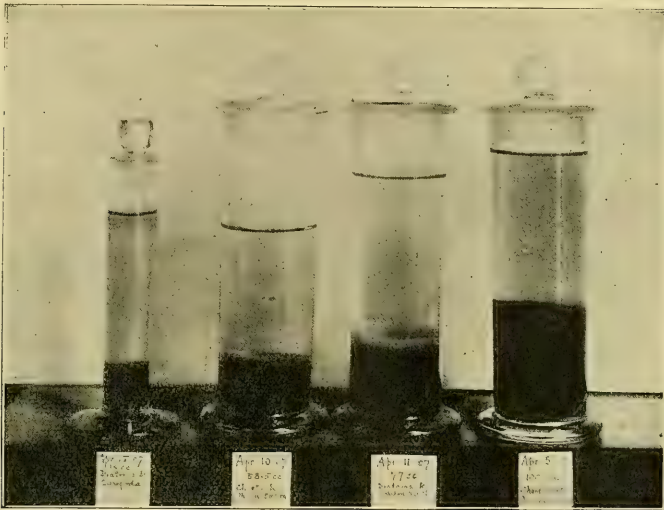


FIG. 4.—Samples of Phyto-plankton from the Irish Sea, about the time of the vernal maximum.

in Kilbrennan Sound on the west of Arran, on July 26th, 1907, consists of a coarse zoo-plankton, in which, however, there are many small Copepoda (*Pseudocalanus* and *Oithona*) and other animals (*Oikopleura* and larval forms) and a few Peridinians and Diatoms (*Rhizosolenia semispina*), mixed with the large Calanoid Copepods.

There are four vertical hauls taken in 1908 and 1910 off Ardmore, Mull, in the centre of the channel between Mull and Ardnamurchan. These and a vertical haul taken in the neighbouring Loch Sunart, in 1910, are all alike in general character, consisting of a fine greenish phyto-plankton mixed with some small Copepoda and a few *Oikopleura*. The Diatoms are, in all cases, mostly species of *Chaetoceros* (*C. contortum* and *C. decipiens*) and of *Thalassiosira* (*T. gravida* and *T. Nordenskioldii*).

Again, the six hauls taken in Loch Hourn, off the Sound of Sleat, a little further up the coast, and the three taken in the closely adjacent Loch Nevis are all very much alike in character, but differ from those of Mull; consisting, as they do, of small catches of zoo-plankton composed mainly of small Copepoda, some young *Nyctiphanes*, *Sagitta*, Polychæt larvæ, a few Peridinians, and many Tintinnidæ.

The gatherings taken inside these neighbouring lochs in the mainland contrast markedly with hauls taken at the same time of year in the open sea further west, *e. g.*, off the Islands of Canna and Rum.

A vertical haul from 85 faths. on July 19th, 1910, between Eigg and Rum, and another on July 14th, from 128 faths., between Canna and Rum, show well-marked green-coloured phyto-plankton; and other hauls off Canna on July 13th and 14th in the same year, from depths of 80, 105, and

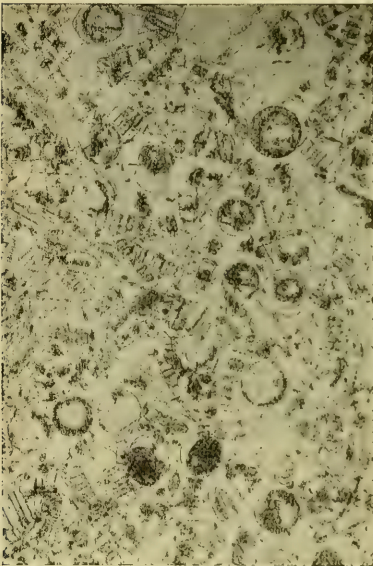


FIG. 5.—A typical Phyto-plankton gathering: from a photo-micrograph by Mr. Edwin Thompson.



FIG. 6.—A typical coarse Zoo-plankton (*Calanus*): from a photo-micrograph by Mr. Edwin Thompson.

130 faths., are also characteristic phyto-plankton gatherings composed chiefly of common species of *Chaetoceros*.

The contrast between such a green Diatom haul taken in the sea of the Hebrides off Canna, in July, and a similarly captured haul at the entrance to Loch Fyne at the same time of year is most marked, the first being a typical fine phyto-plankton (such as fig. 5) and the latter a typical coarse zoo-plankton (fig. 6). As I shall show below, two such gatherings if obtained

in the Irish Sea would be regarded as characteristic of two distinct seasons of the year, months apart.

The difference between the Diatom hauls in the open sea and the fine zoo-plankton hauls in the deep fiords running into the mainland, such as Loch Nevis and Loch Hourn, is not so marked, but is still quite noticeable.

Hauls taken further north, on the other side of Skye, in the Sound of Raasay, off Longa Island and off the Croulins, from depths of 106, 116, and 133 faths., are all zoo-planktons, although not very large or characteristic in appearance. Some are coarser and some finer, some have more Calanoid Copepoda and *Sagitta* and Medusæ than others, but there does not seem to be the constancy of character obtained in some other West Highland localities. Further south, again, in the Firth of Lorne and the Lynn of Morven, off Bernera Island, and between Kerrera and Mull, from depths of 80 to 116 faths., the gatherings, of which we have half a dozen for comparison, are composed of a very fine material, chiefly zoo-planktonic, consisting of small Copepoda, many Nauplii and Tintinnidæ, some *Sagitta* and *Oikopleura*, with a few *Ceratium*, *Peridinium*, and Diatoms; and the latter when present are mainly *Coscinodiscus concinnus* rather than the species of *Chatoceros* and *Thalassiosira* which are so abundant to the north of Mull.

If the hauls from these various localities are marked P or Z, according as they are mainly Phyto-plankton or mainly Zoo-plankton, the list comes out as follows:—

DATE.	DEPTH IN FATHS.	NO. OF HAULS.	Zoo- or PHYTO-PLANKTON.	REMARKS.
<i>Off Ardmore, Mull.</i>				
July 13, '09 ..	94	1	P.	} With some small Copepoda, Nauplii, &c.
„ 18, '10 ..	65, 74, & 85	3	P.	
<i>Loch Hourn.</i>				
July 15, '09 ..	76 & 90	2	Z.	
„ 17, '08 ..	73 & 78	4	Z.	
<i>Loch Nevis.</i>				
July 14, '09 ..	75	1	Z.	
„ 17, '08 ..	70	2	Z.	
<i>Off Croulin and Longa.</i>				
July 16, '09] ..	133	1	Z.	
„ 18, '08 ..	65 & 70	2	Z.	
„ 20, '08 ..	106 & 116	2	Z.	
<i>Firth of Lorn.</i>				
July 21, '09 ..	80 & 110	2	Z.	} A few Diatoms and Peridinians present.
„ 22, '10 ..	108, 110, & 116	3	Z.	

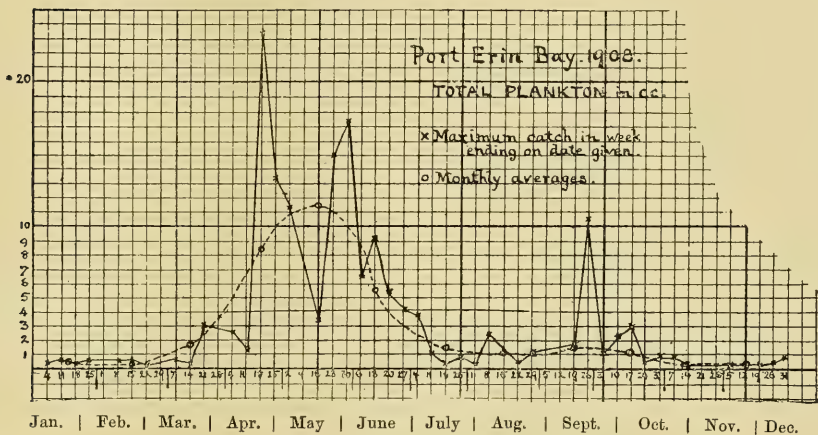
DATE.	DEPTH IN FATHS.	NO. OF HAULS.	ZOO- OR PHYTO-PLANKTON.	REMARKS.
<i>Off Canna, Rum, &c.</i>				
July 13, '09 ..	130	1	P.	} With some small Copepoda and a few other small animals.
" 14, '10 ..	80, 105, 128	3	P.	
" 19, '10 ..	85	1	P.	
<i>Skate Island.</i>				
July 18, '07 ..	104	1	Z.	
" 28, '08 ..	83 & 95 to 105	4	Z.	
" 28, '09 ..	100 to 106	4	Z.	
<i>Upper Loch Fyne.</i>				
July 28 & 29, '08	54 to 66	4	Z.	
" 29, '09....	70	1	Z.	
<i>Arran, Sound of Bute, &c.</i>				
July 26, '07 ..	76-80	1	Z.	
" 27, '07 ..	76	1	Z.	
" 30, '08 ..	95	1	Z. (mixed)	Diatoms also present.
" 30, '09 ..	80	1	Z.	A few Diatoms.
" 31, '08 ..	54	2	Z. (mixed)	A few Diatoms and Peridinians.
Aug. 1, '10 ..	70	1	P.	Copepoda, &c., present also.
<i>Irish Sea.—Mid-Channel.</i>				
Apr. 7, '09 ..	60	4	P.	} Typical spring phyto-Plank- ton.
" 8, '09 ..	60	5	P.	
Aug. 6, '09 ..	59 to 60	5	Z.	
" 7, '09 ..	60 to 70	4	Z.	
" 10, '09 ..	60 to 73	4	Z. (mixed)	} A few Diatoms present.
" 17, '08 ..	60 to 70	6	Z. (mixed)	
" 24, '07 ..	60	10	Z. (mixed)	
Sept. 4, '07 ..	60	12	Z.	
" 12, '07 ..	60	6	Z. (mixed)	} Diatoms getting more nu- merous.
" 12, '08 ..	60 & 70	2	Z. (mixed)	

Thus we have evidence that, off the north-west coast of Scotland at one time of year (July), in several successive years the plankton, as sampled by vertical hauls, was of different types (zoo- and phyto-plankton) in different localities, but preserved a constant character in each.

Now, in the Irish Sea, around the Isle of Man, when the plankton of the whole year is considered, it is clear that neighbouring localities do not present widely different characters as they do in the Hebrides, and that a zoo-plankton and a phyto-plankton do not occur simultaneously a few miles apart. In spring or early summer, in the Irish Sea, as elsewhere, there is an enormous phyto-plankton maximum (see Table, p. 35, column D), which gradually dies away, and is replaced by the zoo-plankton which is characteristic of the summer months (Table, col. E). In September or October, again, Diatoms make their appearance in profusion, constituting a second, autumnal, phyto-

plankton maximum (Table, col. F). The accompanying diagram (fig. 7) shows, *e. g.*, the curve for the whole plankton in the year 1908, as given by a very large series of gatherings *, extending over every month, taken across Port Erin Bay. The high points in April and May, and then again, but to a less extent, in September and October, show the influence of the vernal and autumnal phyto-plankton maxima, and the effect would, of course, be still more marked in the curve showing the Diatoms alone. Taking the average of the last three years in Port Erin Bay, we find that the monthly averages for the total plankton begin low in January and February, rise in March and still more in April, reach the maximum in May, drop rapidly

FIG. 7.



through June, July, and August to the summer minimum, rise a little in September and October to form the autumnal maximum, and fall again in November and December to the mid-winter minimum. The autumnal maximum is always very much less than the vernal, and is sometimes scarcely apparent. Both are caused by a very marked increase in the phyto-plankton, chiefly Diatoms (see lists in Table, p. 35); and the species which are the most abundant and characteristic at the two seasons are, for the most part, distinct †. In summer, when the phyto-plankton is practically absent, the zoo-plankton reaches its maximum; but, in bulk, even at the maximum, the zoo-plankton, except on rare occasions, is small compared with the spring gatherings of phyto-plankton (see columns D and E). A phyto-plankton gathering in the Irish Sea is practically only obtainable in spring or in late autumn; and if the gathering be a very large one (like D in the Table), it is

* See Trans. Biol. Soc. Liverpool, vol. xxiii. p. 244 (1909).

† See *op. cit.* vol. xxii. p. 202 (1908).

certain to have been taken at the former period, say, between the middle of March and the middle of May.

But in the Hebrides, as we have seen, very large phyto-plankton hauls may be taken year after year in July—when in the Irish Sea the hauls are, for the most part, comparatively small, and are all composed of zoo-plankton. Mr. Andrew Scott, A.L.S., who has been associated with me for some years in studying the plankton of the Irish Sea, remarked, when I showed him some of the phyto-plankton samples from Canna, Rum, and Ardmore: “If I had not seen the locality and date on the bottles, I should have placed them, without doubt, as Irish Sea gatherings taken in April.” And the resemblance, I may add, is not merely in general appearance, but extends to the microscopic composition. The gatherings from Ardmore, for example, contain abundance of *Chaetoceros contortum* and *C. decipiens*, *Rhizosolenia semispina*, *Lauderia borealis*, *Thalassiosira gravida*, and *T. Nordenskiöldii*—all of them Diatoms that are characteristic of an April gathering in the Irish Sea, off Port Erin. The abundance of the two species of *Thalassiosira* makes this and other July gatherings from round Canna and Mull quite unlike a September Diatom haul in the Irish Sea, as the genus *Thalassiosira*, abundant in the North, is practically absent at the time of the autumnal maximum in the South.

In order to demonstrate still further the characters of these diverse planktons, and illustrate the comparison between the Scottish summer series and Irish Sea gatherings typical of different seasons, I give on p. 35 in tabular form the quantitative details* of:—

- (A) A typical coarse zoo-plankton from off Skate Island at the entrance to Loch Fyne, July 18th.
- (B) A zoo-plankton of somewhat different type (with fewer *Calanus*, but many more of the smaller Copepoda), from Kilbrennan Sound, July 26th.
- (C) A mixed gathering, mainly phyto-plankton, from off Loch Ranza, Arran, July 27th.

These three somewhat diverse samples were obtained, it will be noticed, within a period of ten days, in July, from localities not ten miles apart.

I add also, for comparison, the similar quantitative record of three characteristic gatherings made in the centre of the Irish Sea, off the west coast of the Isle of Man, near Port Erin, as follows:—

- (D) A typical phyto-plankton, taken in April—a large haul (100 c.c.).
- (E) A typical scanty zoo-plankton, from August (2·5 c.c.).
- (F) A mixed gathering, mainly phyto-plankton, in September, when the autumnal Diatoms are present in quantities (11 c.c.).

* The enumeration of the species in these quantitative lists was made by Mr. Andrew Scott, A.L.S., for our joint report on the Irish Sea plankton. I am indebted to my friend Mr. Edwin Thompson for the photo-micrographs from which figs. 5 and 6 were prepared.

Locality	WEST OF SCOTLAND.			IRISH SEA.		
	L. Fyne.	Kilbrennan.	L. Ranza.	P. Erin.	P. Erin.	P. Erin.
Date	July 18.	July 26.	July 27.	April 5.	Aug. 21.	Sept. 12.
Depth in fathoms	104	76-80	0	20-10	20-0	0
Catch in c.cm.	30	28	11	100	2.5	11
	A	B	C	D	E	F
Asterionella Bleakeleyi .....	...	...	...	15,000	...	1,200
Biddulphia mobiliensis .....	...	...	...	15,000	25	...
Chaetoceros contortum .....	...	...	...	14,000,000	...	...
" debile .....	...	...	500	...	...	3,000
" decepiens	100	...	4,500	50,000	...	8,000
" teres	100	...	...	50,000	...	60,000
" subtile	300	...	3,000	...	...	140,000
" boreale .....	...	500	5,500	...	...	...
" densum .....	...	...	1,000	...	...	...
Coscinodiscus concinnus .....	...	...	...	15,000	...	2,500
" radiatus .....	...	...	500	...	...	1,250
Ditylium Brightwellii .....	...	...	...	...	...	2,500
Eucampia zodiacus .....	...	...	...	...	...	4,000
Melosira Borreri .....	...	...	...	...	...	5,000
Rhizosolenia semispina	800	15,500	1,735,000	...	...	16,000,000
" Shrubsolei .....	...	...	4,000	...	...	20,000
" Stolterfothii .....	...	...	15,000	...	...	30,000
Thalassiosira gravida .....	...	...	...	90,000	...	...
" Nordenskiöldii .....	...	...	...	2,000,000	...	...
Lauderia borealis .....	...	...	...	600,000	...	120,000
Leptocylindrus danicus .....	...	...	500	...	...	...
" sp. ....	...	...	...	...	...	50,000
Pleurosigma sp. ....	...	...	500	...	...	...
Rhizosolenia setigera .....	...	...	...	...	...	2,500
" alata .....	...	...	...	...	...	150,000
Trochiscia sp. ....	...	...	1,000	...	...	...
Ceratium furca .....	...	...	...	...	...	7,500
" fusus .....	...	...	500	...	25	17,000
" tripos	800	6,000	2,500	...	100	50,000
Peridinium sp. ....	...	2,500	300	...	50	...
Medusoid gonophores	1	...	150	...	...	7
Plutei of Echinoderms	200	500	1,250	...	...	...
Sagitta bipunctata	2	15	...	...	30	...
Larval Polychæta	100	...	...	...	...	...
" Mitraria"	200	1,000	1,500	...	...	...
Crab zoea	20	...	...	6	...	...
Podon intermedium	20	100	...	...	20	...
Evadne nordmanni	100	1,600	1,250	...	...	...
Calanus helgolandicus	13,000	4,600	50	...	10	11
Pseudocalanus elongatus	3,460	48,700	150	250	300	60
Temora longicornis	20	200	...	225	65	...
Centropages hamatus .....	...	500	100	...	5	20
" typica	120	...	...	...	...	...
Acartia clausi	240	1,000	200	300	110	900
Oithona similis	1,880	11,000	1,250	200	1,000	250
Paracalanus parvus .....	...	...	...	...	...	80
Copepod nauplii	12,000	18,500	45,000	...	2,000	9,000
" Juv.	8,000	48,500	15,000	...	500	3,800
Gasteropods, larval .....	...	500	500	...	25	...
Lamellibranchs, larval .....	...	500	600	...	50	...
Oikopleura sp.	30	1,000	600	1,500	500	10

It will be noticed, in comparing the Loch Ranza plankton with the Irish Sea hauls in April and September, that in species present and their abundance, the Scottish July gathering is much more like the September than the April phyto-plankton—for example, in both July and September the most abundant form is *Rhizosolenia semispina*, a species absent in April. But, as has been pointed out above, the phyto-plankton gatherings north of Mull show resemblances to the vernal rather than to the autumnal phyto-plankton of the Irish Sea.

It is probably premature to hazard any suggestion as to the explanation of this curious difference between the summer planktons in the Hebridean and the Irish Sea respectively. It may be that the great vernal maximum which dies away in May and June in the Irish Sea passes off more slowly further north, and is still found lingering on in some parts of the Hebrides until the end of July, or possibly even longer. Or it may be that, in some of these deep northern channels, the Diatoms that elsewhere constitute our vernal maximum remain on in comparative abundance throughout the greater part of the year. Still a third possible explanation is that the Diatoms constituting these July phyto-plankton gatherings may have invaded the Hebridean seas from the North Atlantic at some period subsequent to the vernal maximum. It is obvious that such a question can only be determined by frequent periodic observations carried on throughout the year by means of vertical hauls at fixed localities. Such series of observations have still to be made in the Scottish seas. Mr. George Murray, in 1896, took some series of horizontal tow-net gatherings at various localities round the coast of Scotland for the Scottish Fishery Board, and he published a brief report* the following year on his results. His observations were made in March, July, August, and December, and were widespread, including several of the localities I have sampled; but they seem to deal mainly, if not wholly, with the surface of the sea, and in any case do not include vertical hauls in deep water. But it is interesting to note that his results, so far as they go, are not inconsistent with the observations I have given above. Murray states that after the vernal maximum the Diatoms diminish, but do not disappear, and are to be found throughout the summer in local banks. *Skeletonema costatum* he notes as the most abundant and characteristic form on the surface generally in April, and in Loch Etive in August: this species occurred only occasionally in our July hauls.

The table he gives shows that there were fewer species of Diatoms in Loch Nevis and Loch Hourn than in the sea between Rum and Ardnamurchan—there being 28 in the latter column and only 7 in that for Loch Nevis. So far this comparison agrees with the abundant phyto-plankton gatherings we obtained off Rum and Canna, &c., and the comparatively small catches

* S. F. B. Report for 1896, vol. xv. part iii. p. 212.



FIG. 8.—West Coast of Scotland, showing depths of over 50 (shaded) and over 100 (black outline) fathoms. Twenty-five stations at which deep hauls were taken are marked by a small black circle enclosing a cross.

of zoo-plankton in the lochs on the mainland; but our hauls being vertical from the bottom at great depths probably sampled a much larger body of phyto-plankton, and included some species that did not appear at the surface.

It may be added that Prof. P. T. Cleve gave a short account, in the Scottish Fishery Board's Report for 1896, p. 297, of the phyto-plankton of the 'Research' collections made in the Shetlands, and showed that the stations on the western side were rich in Diatoms, while the hauls taken from the east of the islands were much poorer—this, again, showing a difference between not very distant localities at the same time of year.

The Scottish Fishery Board do not seem to have published any further investigations in regard to plankton in their western seas; nor does the Irish Fishery Department give any information in regard to the minuter plankton of the seas between Scotland and Ireland: apparently only coarse-meshed nets have been used by the Irish investigators, and no Diatoms are given in the published tables (Conseil Per. Internat., Bull. Trimestriel, 1907-8, Copenhagen, 1909), which deal with zoo-plankton alone. Finally, the map giving the stations in European seas at which plankton observations have been taken in recent years (*loc. cit.*, Résumé Planktonique, Introduction, p. xii, 1910) shows a great gap extending from near Cape Wrath, in the north of Scotland, to Belfast Lough in Ireland. The whole of the seas around the Western Islands of Scotland, like the western coasts of England and Wales, have apparently been omitted from the Official International investigation.

This is, from the scientific point of view, most unfortunate, as, for a complete understanding of the plankton changes throughout the year, in the Irish Sea at least, it would be useful, and may be essential, to have information as to the planktonic conditions month by month on the north coast of Ireland and on the west coast of Scotland.

The unofficial observations recorded in this paper have shown that, while the abundant vernal phyto-plankton dies away in the Irish Sea in early summer, a similar micro-flora is present in quantity in some parts of the sea on the west of Scotland (*e. g.*, the Sound of Mull, and the sea round Canna, Eigg, &c.) until July, and possibly latter. It can scarcely be doubted that the phyto-plankton maximum is found in spring in the Hebrides as in the Irish Sea. But have the July Diatoms remained since April, or did they die off (as they do further south) and then re-appear? If the latter, have they come from the Atlantic or from northern seas? Do they continue to be abundant throughout the remainder of summer and autumn? Are any of them left in the deeper channels in winter? These and many other problems press for solution, and will probably only be solved by continuous plankton work throughout the year at a series of stations along our western coasts.